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Lubrication

A Technical Publication Devoted to the Selection and Use of Lubricants

THIS ISSUE

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Careless Handling

Protection of Lubrication

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Common Faults in Lubrication

Careless Handling

IN conjunction with protective storage of lubricants, it is important to realize that careless handling can also lead to serious contamination; to the end that an oil or grease can have its lubricating ability seriously impaired before it is even put to work. For this reason the methods and machinery of efficient handling of lubricants must be thoroughly understood, and the potential detriments of carelessness fully realized.

Bulk Handling and Delivery

In this connection, methods of bulk handling and delivery of lubricants must be given first thought. In general, these will include:

1. Bulk delivery by tank car or boat, or
2. Truck delivery of steel drums, barrels, or cans.

The location of the tanks with respect to the delivery level is important where bulk transportation is practiced. In such plants the lubricants are transferred from the tank car or boat through hose connections. To expedite discharge and reduce expense, gravity flow should be taken advantage of wherever possible by locating storage tank filling hatches below the level of the outlet valve of the tank car. With boat delivery, however, this simple procedure cannot always be followed, and oils must normally be pumped from the ship's tanks to shore storage.

Package delivery, as the shipment of lubricants in drums, barrels, or cans, is usually termed, will also be facilitated if gravity is made use of to the fullest extent.

Temperature Control

Wasteful or sloppy handling of lubricants can frequently be prevented by care in control of oil house and tank temperatures. It can be realized that where ready fluidity is assured less time will be required in drawing oil supplied and, furthermore, drip will be reduced. In consequence, thermal conditions should always be studied in planning storage tank location in either an oil house or an oil room. Basement or sub-surface location for the entire tank or at least a major part of it should be planned for wherever possible, inasmuch as that portion below the floor or ground level will not be subjected to as great a variation in temperature, provided the building is of relatively solid construction.

In many such installations the temperature can be so easily controlled that it will be possible to close the basement sufficiently by means of sealed trap doors, etc., to maintain the entire room at the requisite temperature for pumping even the heavier oils and still keep the delivery or pumping room above comfortable.

Wherever heavy, viscous products such as valve and cylinder oils, gear compounds, etc., are to be regularly stored, however, the oil house or oil room should always be equipped with steam heating coils, especially where climatic temperatures may vary over a wide range.

In this way the temperature of the entire house or room can be accurately regulated, overheating will not be so apt to cause damage to certain products, and heating can be econom-

ically carried out by the use of exhaust steam in practically all cases.

Heating of semi-solid lubricants to facilitate handling can be effectively accomplished by surrounding the exterior of the tanks with steam coils near the suction or draw off line. Thus heating of the entire tank is avoided, and considerable steam can be saved, yet with the attainment of entirely satisfactory results.

Tank Design and Installation

In planning an oil house storage tank installation horizontal location of all larger tanks will always be advisable, in order to obtain maximum distribution of the load on the foundations and reduce the load per unit of area as much as possible. Thereby the possibility of settling will be decreased and excessively heavy footings and foundations will not be as necessary to carry a load which is relatively widely distributed, provided the ground on which they are to be built is solid and not prone to settle.

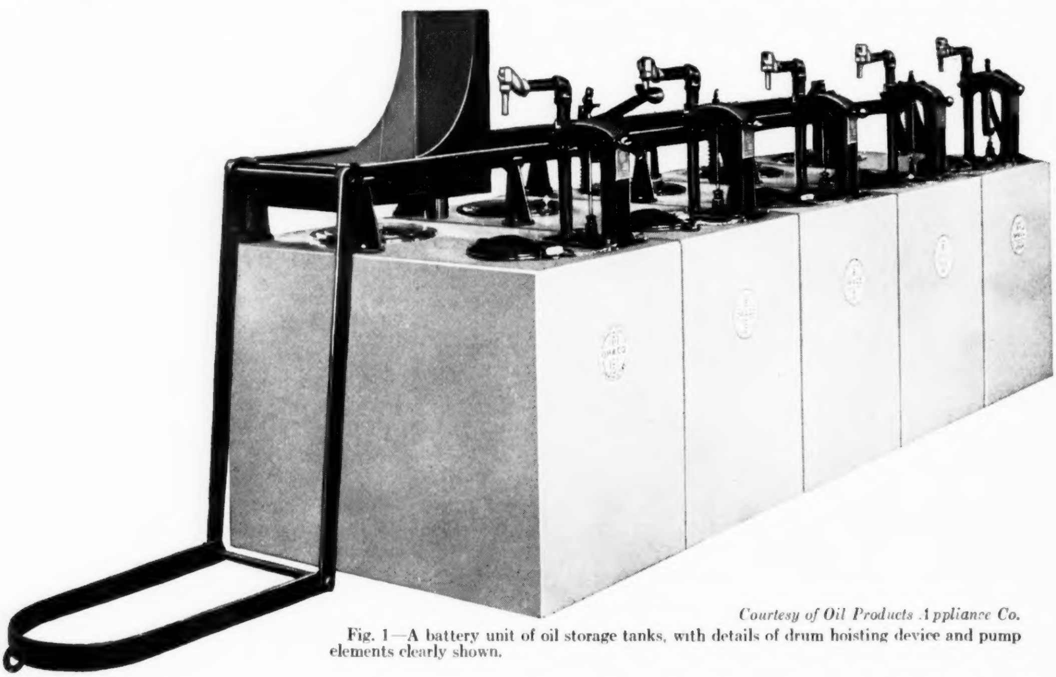
To insure complete and permanent rigidity, the tanks should always be securely anchored to their foundations,—never just rested upon the latter. This will be especially essential in localities where floods, earth movements or explosions, etc., are possibilities, the occurrence of which might disturb the location of tanks and cause broken pipe connections, damage to floors, leaks and loss of oil.

Oil Storage Equipment

Complete protection of lubricants in storage, however, is not entirely assured by proper oil house construction and tank design; auxiliary equipment for the handling of the products must be given careful attention. This will involve pumps, meters or other measuring devices, portable elevators for hoisting or lowering barrels, and other conveying equipment.

For the handling of fluid lubricants out of any form of storage tank, sealed pumps should be used wherever practicable. In many cases pumps for this purpose are built to meter or measure automatically the amount of oil withdrawn. A measuring device of some sort is always advisable in order that the oil consumption of the plant or any of its departments can be checked wherever desired, and to facilitate keeping lubrication records. Measuring pumps will save considerable time and labor, will enable the oil house or oil room attendants to fill orders promptly, and will insure that the oils are kept free from contamination and in their original state of purity, at least until they are drawn into the distributing containers.

The value of orderly oil house operation, and properly kept records of daily, weekly and monthly oil consumption, should never be under estimated. The effect on the morale of the plant and the economies in consumption of lubricants that can be attained, will be surprising where employes must follow a definite procedure in obtaining their necessary oil supplies, and where an accurate record of consumption is kept. This matter of everybody's helper running to the oil tank with a half-pint can should be stopped. It is the main



Courtesy of Oil Products Appliance Co.

Fig. 1—A battery unit of oil storage tanks, with details of drum hoisting device and pump elements clearly shown.

reason for the majority of complaints regarding machine breakdowns, excessive oil consumption and bearing troubles.

Hoisting and Transferring Equipment

Bulk storage of lubricating oils in particular will require hoisting of barrels or drums to the top of storage tanks, or to emptying racks for transference of their contents. Where this is necessary it will be advisable to install a portable elevator for the purpose of raising and lowering these containers, to eliminate handling and the chance of damage as much as possible. It can be readily appreciated that a dead weight of from 400 to 500 pounds will tax the strength of two average men, and for this reason barrels are often dropped, damaged, and their contents partly lost or contaminated.

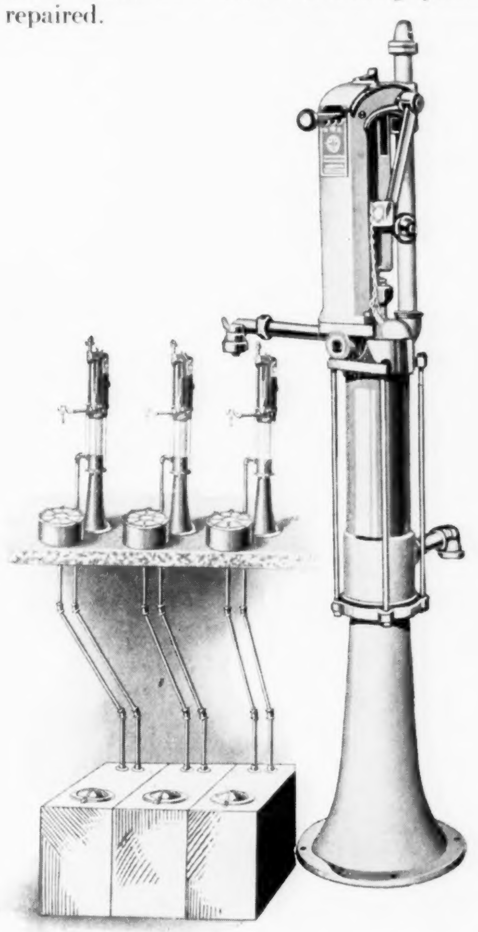
Along with an elevating device as above, a suitable track can be extended along the tops of all tanks which are to be filled from barrels or drums, at a sufficient height above them to facilitate location of the bungs directly over the filling hatches. This will reduce the possibility of waste. Containers can then be hoisted to this track level, rolled into position above the respective tanks to be filled, and emptied of their contents rapidly and completely, with very little labor and minimum waste.

Manner of Distribution of Lubricants

The greatest possibility of sloppiness and contamination, however, will develop in the distribution of lubricants from the oil house or oil room. Furthermore, this will involve a certain amount of time lost on the part of the employes who are to deliver the oils and greases. So this should essentially be studied as a cleanliness and labor-saving problem.

As a general rule, the manner of distribution will depend upon the location and number of units that are to be served. Where many buildings and departments are involved it will often be practicable and most economical to make deliveries by motor truck, covering perhaps the entire plant at one trip. Other plants which involve but one or two buildings can probably be served by hand truck delivery. In any case it will often be found advisable to supply individual departments with sufficient gallonage at a time in order to reduce oil house labor and transportation expense.

Where force feed, gravity, or other forms of automatic circulation lubricating systems are involved which require addition of new oil at more or less infrequent intervals, the necessity of keeping an extensive auxiliary supply of oil on hand is practically eliminated. In such cases small hand oiling cans for emergency usage will suffice, because failure in the lubricating system of a turbine, for example, will usually require prompt shut-down in any event. Reciprocating engines, on the other hand, can be frequently kept in operation while any normal failures in their lubricating systems are repaired.



Courtesy of Oil Products Appliance Co.

Fig. 2—Outline view of a series of pump and storage tank units, wherein storage tanks are located in the basement of the oil room, the pumps being on the main operating floor.

Where auxiliary storage in individual departments is to be maintained the type of containers used is important. Preferably they should be of the cabinet type of storage tank, fitted with a suitable hinged cover to afford the utmost protection of the contents. Such tanks should be equipped with measuring pumps, and so built that any drip from the pump discharge drains right back into the tank in order to avoid waste and sloppiness.

Where a considerable gallonage of oil is used in any specific department it may often be found advisable to lay a pipe line (or lines) directly to this locality from the oil house, with connections to suitable pumps therein. Thus the requisite products can be pumped directly from the storage tanks to the point of con-

sumption with a minimum of labor, waste and chance of contamination.

The Storage of Semi-Solid Lubricants

The extent to which greases, gear compounds and petrolatums are used will be another factor that must be considered in planning the oil house layout. Such products are customarily shipped in steel barrels of standard size, small drums or in cans of one, five and twenty-five pounds capacity. When received in smaller quantities the lubricant is usually not transferred from the container to any main storage tank, being used directly from the shipping container.

Where barrel shipments are involved in any considerable number, however, oftentimes provision for central storage of the products will be desirable, as has already been briefly stated. Such of these compounds as can be rendered fluid through reasonable heating can be handled like oils, their storage tanks being built with similar filling hatches, rolling tracks and elevator equipment. Thus upon receipt at the plant in large amounts, the steam heat can be turned on in the oil room and barrels promptly hoisted for draining of their contents with a minimum of loss into the respective tanks set aside for their storage.

In this connection it is well to emphasize again the importance of accurate regulation of steam flow and oil room temperature especially at such a time. When gear compounds are to be transferred from shipping containers to storage tanks, whatever the atmospheric temperature it will be usually necessary to raise them (through indirect heating) to approximately 150 degrees Fahr., in order to enable them to flow readily and rapidly from the bung holes.

Where compounds are too heavy to flow with any degree of rapidity under reasonable heating they must be stored in the shipping containers. In general they can be best handled by a clean paddle or spoon, removing only a sufficient amount to fill the containers each time.

In the case of harder grades of products such as certain railway lubricants, it may be necessary to cut the requisite quantity from the contents of the barrels, in blocks with a knife, inasmuch as such products are altogether too hard to dig into with a paddle or spoon.

To protect the contents of the barrels after the heads have been removed, a removable cover should always be kept tightly in place over the top. Sheet metal is considered the best material for such a cover and preferable to wood as it insures a better seal.

Protection of Lubrication

Air Filtration and Oil Purification

ALL industrial machinery is subject to the detriments of dirty air. Certain equipment such as the air compressor, Diesel or gasoline engine in addition will actually have to take this air into their working elements in the performance of their intended functions. Others, including much of the actual process or fabricating machinery of industry, will operate in dust laden atmosphere to the almost positive detriment of such bearings, gears or chains, as may be exposed or so constructed that dirty air may have access thereto.

It is of course impossible to eliminate dirty air conditions entirely; screening of windows and doors will prevent larger particles of dust from entering, but finer dust will get by to be an ever prevalent detriment to lubrication unless steps are taken to remove it from the air which is to pass through the equipment or come in contact with its wearing elements.

Such air, therefore, should be filtered whereever necessary, the volume so treated per hour, generally depending upon the size of the filter installation and the requirements of the plant. Normally it will not be necessary to filter all the air which is circulated through any particular room or building. In general only such air will require filtering as is to be taken into air compressors, oil engines, etc., or is to come into direct contact with electrical equipment.

Principle of Air Filtration

In view of the evident relation which exists between lubrication and cleanliness, it is decidedly important to know more about this matter of air cleaning or filtering, and the systems devised for its accomplishment.

The modern air filter is based on the principle of the human nostril, in that by suitable arrangement of the filtering media and certain baffles, the passage of dust is arrested even though there is free access for the air. As the filter becomes clogged or its pores or interstices filled with foreign matter, air will pass through with more or less difficulty. It is for this reason that periodic cleaning is necessary.

Construction of Air Filters

The air filters for general industrial or power plant service will as a rule involve a suitable container, cell or box in which is contained fine wire such as crimped wire, expanded metal sheets, small metallic cylinders or felt vanes, etc.

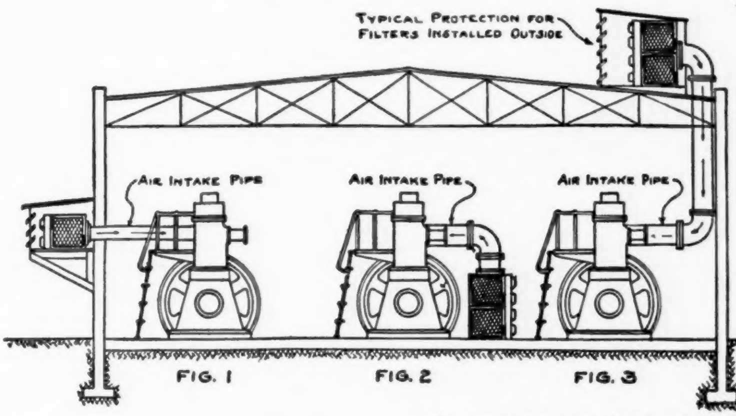
Where metallic filtering material is used it is regarded as advisable to grade it in coarseness from intake to outlet, the finest media being located adjacent to the clean air outlet. To aid further in the separation of dust from the air certain authorities deem it advisable to provide for repeated change in direction of the latter. In one type of filter involving crimped wire for filtration, the direction of the air is claimed to be changed from eleven to eighteen times. Each change, of course, tends to throw a certain amount of dust into more intimate contact with the filtering media, to be retained and prevented from further passage through the filter. When metallic filtering material is involved, it will be necessary to have it coated with a light film of an adhesive fluid in order to promote retention of solid foreign matter. Light lubricating oil having a viscosity of from 200 to 300 seconds Saybolt at 100 degrees Fahr., has proven to be suitable for this purpose.

Importance of Cleaning

The continuous filtration of dust-laden air will, of course, result in accumulations of foreign matter within the filtering media. The extent to which these build up will depend upon the normal dust-content of the raw air. In any event, more or less resistance will be presented to restrict free passage of air, with the result that the amount of air delivered (which is in reality a measure of the efficiency of the filter) will be reduced.

Consequently it will be necessary to clean the filter cells at regular intervals. The average frequency of cleaning in most industrial plants will range from one to three months. Cleaning of metallic filters can be effectively carried out by use of a hot soda solution in a vat or tank of suitable size. Soda effectively "cuts" or dissolves dust, dirt, grease and oil, hence by dipping and sluicing the cells in such a solution the filtering media can be brought back to condition, the pores cleaned and the entire device rendered once again fit for developing maximum efficiency. Metallic filters which manufacturers recommend coating with oil or any other dust-absorbing fluid should be redipped in such a medium after cleaning, being allowed to drain off any excess oil, etc., before replacement in the bank.

Felt vane filters can be cleaned in place, by blowing air through, from the inside of the inserts. This effectively removes dry dust accumulations from the exterior surfaces.



Courtesy of American Air Filters Co., Inc.

Fig. 3—Three methods in which an air filter can be installed on an oil engine, according to location of intake.

In Diesel Engine Operation

Air which must be used in connection with Diesel engine operation for scavenging and combustion should be as clean and free from abrasive foreign matter as possible. Of course, this will be most important in the full Diesel engine where air is not only mixed with the fuel prior to combustion, but is also used to bring this about. Yet, in the semi-Diesel, it is likewise of importance, for dirty air will preclude efficient operation by increasing deposits and perhaps causing scored cylinders, etc. While all air will contain a certain amount of minute abrasive, foreign matter, of course in certain localities and in certain industries where oil engines are employed this will be far more in evidence than in others.

The marine Diesel engine for example, will usually function on comparatively dust-free air, and therefore might not require any air filtration, whereas, a stationary engine operating in a stone working plant would be a decidedly fit candidate for attention in this regard. Essentially, therefore, the oil engine operator will be confronted with the problem of determining the dust content of the air in his engine room.

Marine Practice

Of course, while a vessel is at sea the air taken into the engine can usually be expected to be pure and clean, yet many times the reverse is true when the ship is in congested

harbors, or loading and unloading alongside a dock. Whereas the main engines will not be in operation in the latter event, yet the protection of the auxiliary Diesel engines furnishing power for the winches, for the galley and heating systems, as well as for the miscellaneous electric pumps and air compressors is of the same grave importance. Filters for cleaning the air on shipboard follow the usual conventional lines of those installed in land practice.

Courtesy of Fairbanks-Morse & Co.
Fig. 4—Longitudinal section through a two-cylinder stationary Diesel engine, showing the automatic lubricating system which provides for the continuous filtration of oil.

Dust a Cause of Deposits

In the counteraction and partial elimination of deposits and so-called carbonaceous matter in the cylinders, etc., of oil engines and oil engine air compressors, it is well to bear in mind that dust and other foreign matter carried in with the air is one of the chief promoters of these evils. In fact, the amount of carbon developed in the normal operation of the average Diesel engine using medium gravity fuel and high grade lubricating oil, will usually be practically negligible.

So it is with the solid, non-combustible matter that we are more distinctly concerned, especially, too, if the fuel as well as the air contains such impurities or is so injected that incomplete combustion takes place. Under such conditions a cementing medium would be developed or left as part of the fuel residue which would soon absorb any dust and dirt carried in with the air, and collect on the piston heads, the walls of the combustion chamber, and even around the rings. The use of an excess of lubricating oil would increase the percentage of potential gummy residue, and not only aid in the formation of deposits but also tend to seal the rings.

It is conceivable that dust and dirt might have a certain catalytic action in this regard, for, as is true in the automobile engine, cylinder deposits are noticeably increased when dirty air is used. In other words, the dirt and dust carried in by the air prevents the burning out of true carbonaceous residues during operation.

Electrical Equipment

To insure effective lubrication of the bearings of electric generators and motors, and to prevent injury to the windings, it is essential to protect them at all times from entry of abrasive foreign matter. In many such installations there will be possibility of the occurrence of windage, that is, the passage of air through the bearings. This will, of course, depend upon bearing construction and whether provisions are installed for counteraction.

In certain of such equipment baffles or dust guards are employed. These latter will effectively reduce windage, and serve to prevent oil being carried from certain types of bearings. But where there is any draft, and the dust content of the air is comparatively high, there will still be considerable probability of abrasive matter penetrating to bearings, or the windings of open motors, etc., to impair operation.

For this reason it will be advisable to give consideration to air conditions, and the potential benefits to be derived from better lubrication by proper filtering of the air.

Babbitted bearings will be the most liable to suffer from abrasive impurities in the air. Ball and roller bearings can as a rule be more tightly sealed by virtue of the nature of their construction. This is important to remember where pressure lubricated generator and turbine bearings are involved.

Air Compressor Service

The fact that efficient air compressor operation is decidedly dependent upon clean air and effective lubrication renders discussion of such equipment of vital importance. Air compressor explosions or failures in after-coolers or any of the connecting lines are chiefly due to accumulation of deposits which restrict the free passage of the air and lead to abnormal temperatures by reason of frictional resistance.

Deposits of this nature may result from continued usage of lubricating oils of high carbon content. They are more liable, however, to be caused by entry of dust along with the air

which is to be compressed. Where such foreign matter is able to pass through with the air the result would not be as serious. There will be a tendency, however, for it to remain in the system, especially where lubricating oil is used to any excess, to result in gummy deposits around valves, in cylinder clearances in intercoolers, after-coolers and air lines.

It is safe to say that all air for compressor service will carry an appreciable amount of fine abrasive dust. The nature of this latter, will, of course, depend upon the elevation and location of the installation. In flat, suburban or farming districts where road traffic may be fairly heavy, winds prevalent, etc., the resultant dust which will be bound to occur will probably be of an earthly or siliceous nature. In contrast, the dust content of the average air in mining or smelting localities, or industrial centers will include ash, coal dust or more or less mineral matter, but of course, all in very finely pulverized condition.

In consequence, steps should be taken whereever possible to protect air compressor equipment and insure effective lubrication by properly filtering the air prior to its being drawn into the system. This means the installation of adequate filtering equipment at the intake.

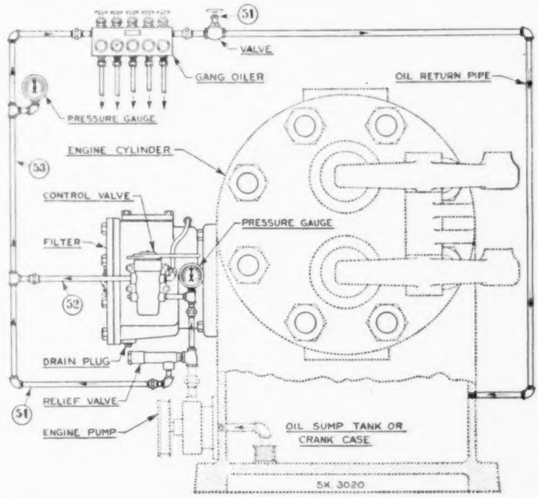
Carbon Deposits

Inasmuch as the lubricating oil may cause, or lead to deposits of more or less intensity, depending upon its carbon content and the operating conditions involved, more discussion in this regard will be of interest.

Deposits of carbon plus dirt on the valves, or in the discharge lines of an air compressor are to a certain extent caused by decomposition of the oil. It is an accepted fact that mineral lubricating oils, regardless of their base or nature, will decompose to volatile products and carbon when subjected to hot air under pressure. The extent of this decomposition of course depends on the length of time the oil is exposed to such heat. Naturally, it will also follow that the oil which remains in the compressor cylinder or on the discharge valves the longest, will form the greatest amount of carbon.

On the other hand, analysis of numerous so-called carbon deposits has proven them to consist more of dirt than of carbon, the whole being held together by gummy matter from decomposed oil. For this reason, a compressor oil having a wide range of distillation, high end point, or too great a viscosity is objectionable, inasmuch as, instead of vaporizing cleanly, it breaks down as has been mentioned above, becoming sticky and collecting dirt brought in by the air. The slower the breaking down process, or the greater the volume of oil involved, the more carbon will ultimately be formed.

Pale filtered oils, properly refined, are very free from both direct carbonization and the collection of carbonaceous matter. Further-



Courtesy of S. F. Bowser & Co., Inc.

Fig. 5—A typical installation of an internal combustion engine lubricating oil filter, showing side elevation of filter mounted on side of engine. When in operation, all carbon particles, dirt, grit, etc., which may have been picked up by the oil will be deposited on plates in the filter.

more, any such direct carbon that may be formed through excessive use is of a light, fluffy nature. Carbon deposits formed from improperly refined or unsuitable oils, on the other hand, are often of a hard flinty nature. Any oil, however, will accumulate dust if the air is dirty.

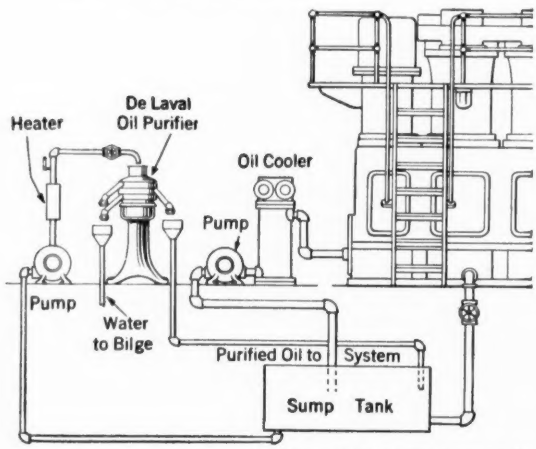
Relation to Explosions

The matter of explosions is of the utmost importance to all who have to deal with air compressor operation and lubrication. Explosions occur due to accumulations of carbonaceous matter becoming heated to the point of combustion when abnormally high temperatures are involved due to leaky valves, either causing the metal to burn through and blow out, or bringing about the ignition of gaseous (oil and air) vapors which may have resulted from oil collections in pockets, etc. Localized vaporous accumulations of this nature will practically always become sufficiently condensed in time to form a "critical" or combustible mixture of air and oil vapor, requiring only intense heat or a spark from incandescent carbon to bring about an explosion.

Two distinct factors, therefore, require consideration, i.e.:

1. The extent to which carbon deposits or accumulations of dust, dirt and oil, etc., are involved, and

2. The generation of excess heat, due either to air leaks in the discharge or final stage of compression, especially at the time of "unloading," or increased velocity of flow through the lines.



Courtesy of The DeLaval Separator Co.

Fig. 6—An arrangement of a continuous by-pass system of purification as applied to an oil engine of the pressure lubricated type for either land or marine service. In the operation of this system, the used oil is delivered from the engine into the sump tank, from which oil is pumped through the cooler and delivered to the engine for further service.

Carbon deposits or "carbonaceous" matter in general, does not strictly denote pure carbon, or in other words, carbonized oil. In fact, the proportion of fixed carbon to volatile matter in many cases will be relatively low.

Silica, iron, copper and zinc have all been found present, proving that a considerable portion of any such deposits can therefore be regarded as consisting of substances which are either drawn in by the original charge of air, or abraded from the metallic parts of the system, the lubricating oil being but partially responsible.

PURIFICATION OF LUBRICATING OILS

Successful lubrication depends first upon the lubricant, second upon the way the lubricant is applied, and third upon the precaution taken to prevent not only its contamination before it is applied, but also to keep it clean in service.

The purification of Diesel engine lubricating oil aims to remove sludge, water and other suspended impurities acquired by the lubricant in the course of its work and to restore the oil to its original condition. Long and efficient service of Diesel lubricating oil can only be assured by proper care of the oil and regular attention to the cleanliness of the oiling systems. Provision must be made, therefore, to remove any accumulation of unavoidable impurities which may gain access to the lubricating oil, depending on the design of the engine.

The formerly believed theory that oil "wore out"—that in constant use day after day it would break down, is now no longer accepted. Lubricating oil does not wear out in Diesel service, although the color of oil which has been purified may be slightly darker than the original oil. The oil may, however, become so polluted from numerous sources that it ceases to be an efficient lubricant. Dirt, water, metallic particles and sand from cast iron parts of the engine form some of the contamination. From the breakdown of oil in the system, various forms of sludge and carbon are formed. Abrasive materials if allowed to remain in the oil will cause excessive wear on lubricated parts.

Sludges and emulsions formed with water and the carbonaceous residues from burnt oil frequently clog passages, causing failure of the supply of oil to bearings, resulting either in quick shut-down or, if not caught in time extensive damage and expensive repair. Obviously, the vast amounts of money and time spent in the refining of lubricants for certain purposes, and in perfecting the technique of their application are wasted if the introduction of foreign matter is allowed to destroy the efficiency of the oil.

TYPES OF SYSTEMS

Lubricating oils can be reconditioned or cleansed by one of three distinct methods, viz.:

By precipitation and filtration.

By centrifugal separation and

By mechanical coagulation of the impurities with suitable chemicals.

Cleansing of lubricants by means of filtration or centrifugal purification is accepted as one of the outstanding factors in the maintenance of effective lubrication. Lubricating oils, today, as refined and marketed by the reputable oil companies, are clean and free from foreign matter.

Refinery, pump house, storage, packing, and transportation methods have all been worked out with purity as the outstanding objective. In consequence turbine oils, steam or Diesel engine bearing lubricants, transformer oils, or those products so extensively known to the railroad man as "car oils," regardless of their wide variety in respect to physical properties, appearance and requirements, are all of proportional purity according to these requirements, when delivered to the ultimate consumer.

In service, they must be kept up to approximately their individual standards of purity, otherwise their lubricating ability will be reduced to a certain extent. It has been claimed that oils do not wear out in service; that they only become contaminated. This would appear to be borne out by the fact that a turbine oil, for example, can be run continuously for months with but a relatively small amount of

make-up necessary to compensate for loss by evaporation or in the process of cleansing. On the other hand, continued service and contamination can rightly be expected to reduce the lubricating ability of any oil.

Precipitation and Filtration

Modern practice in filter construction usually provides for application of the principles of both precipitation and filtration in the same equipment.

Precipitation alone is an extremely lengthy operation, though dependent of course upon the viscosity of the oil and the amount of foreign matter contained. Normally, too much time would be necessary for proper clarification of an oil. The rate of precipitation can be expedited by heating the oil to a certain extent to reduce its body, or, by addition of certain substances which differ sufficiently in specific gravity to increase the rate of settlement of the contained impurities. Over the period of precipitation the oil should, of course, be as quiet as possible, for agitation to any extent would obviously interfere with settlement of heavier material.

In consequence, precipitation is generally resorted to only for partial clarification or removal of larger and relatively heavier particles of foreign matter. Final treatment is carried out by filtration or screening the oil through porous material with openings fine enough to retain the majority of the remaining impurities. Wire cloth or finely woven canvas may be used for this purpose. The extent to which ultimate purification will be attained will depend upon the length of time the oil is treated and the fineness, weave or density of the filter.

It is not usually necessary to attempt to bring an oil completely back to its original state of purity. Too much time and too intricate equipment would be involved. The extent of reconditioning should be based upon the grade of oil under treatment and the service required of it.

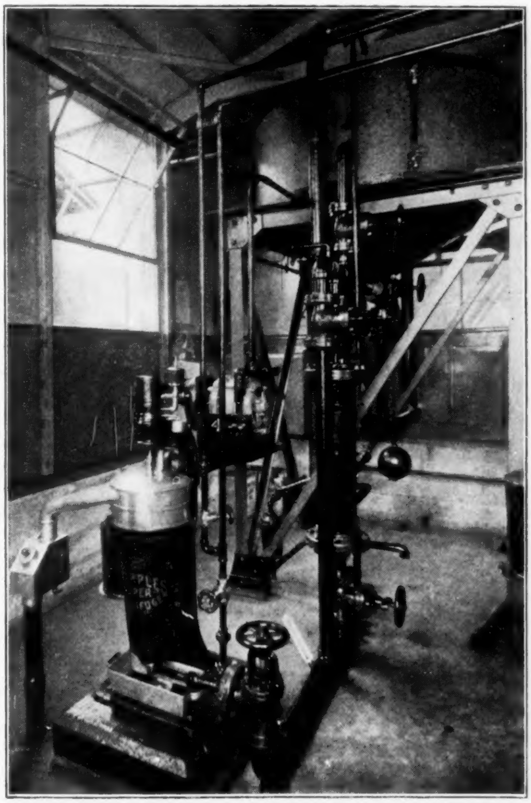
Diesel Engine Practice

The lubricating systems of single-acting engines, whose power cylinders are open to the crankcase, are particularly liable to contamination by foreign impurities. Incombustible matter in the fuel, carbon particles and other impurities may mix with the cylinder oil, and working past the pistons are drained to the crankcase. Over a period of time such impurities may collect in extensive quantities and become a source of real danger.

Contamination is also brought about where engines operate in dusty surroundings and impurities are introduced with the intake air. Such foreign particles, together with mineral dust, may enter the bearings with the lubricant and, as such siliceous matter has a decided scoring or abrasive ability, are apt to cause considerable wear.

Emulsions

Lubricating oil tends to emulsify in the presence of impurities and water. Water caused by condensation or resulting through leakage from the cooling system may produce, in conjunction with carbon and dust, a persistent emulsion. The natural sequences of such emulsions are deposits on cooling coils which will cause their insulation, clogged oil ways restricting oil flow to the bearings, and in some cases failure of the lubricating oil film culminating in bearing troubles.



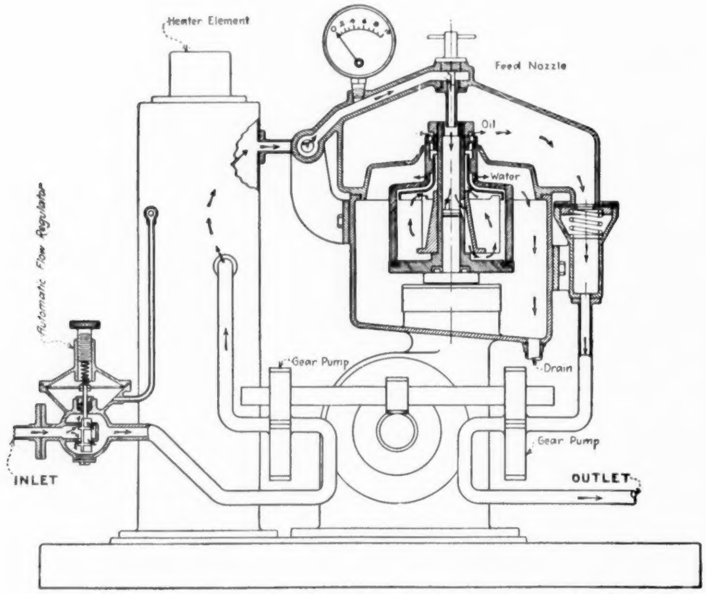
Courtesy of The Sharples Specialty Co.

Fig. 7—Unusual Land Installation for Purifying Ferry Boat Diesel Lubricating Oil.

The presence of iron oxides, such as rust, cause an increase in the rate at which all this may occur; especially will they hamper the separation of water from the oil. The oil in service must, therefore, be kept clean for it must not only lubricate effectively in order to reduce wear, but also it must be capable of protecting the wearing surfaces against rust or corrosion when the engine is shut down.

Oil Oxidation

Double-acting as well as single-acting engines whose power cylinders do not communicate with their respective crankcases are less liable to have the lubricating oil contaminated by fuel, water, other impurities, or by oxidation. This latter condition is more generally brought about by service in a circulation system, and is accelerated by heat and the vaporizing of the lubricant into a fine fog or mist.



Courtesy of The Hydroil Corporation

Fig. 8—Line view of a direct connected, motor driven centrifugal purifier for lubricating and fuel oils equipped with automatic oil flow and heat control. This vapor-tight, self-oiling, ball bearing unit has direct-connected, positive flow, geared pumps.

Some hydrocarbons are soluble in oil while others are insoluble. The former are not deposited at normal operating temperatures. Where there is a sufficient reduction in temperature, however, as on the cold surfaces of cooling coils and in some parts of the lubricating system, they may be precipitated. When such insoluble oxidized hydrocarbons are present in the circulation system they tend to deposit on oil pipes, oil passages, and strainers. Besides increasing the tendency of an oil to emulsify, oxidized hydrocarbons interfere with oil cooling, clog oil piping and may possibly prevent the lubricant reaching the bearings.

Sludge and Carbon

Impurities which may be prevalent in a circulation system will tend to be intimately mixed with the lubricating oil, particularly under such favorable conditions as pressure and heat, when passing between bearing surfaces. During idle periods of the machinery the impurities tend to settle out from the oil, the free water collecting readily at the bottom of the engine base or crankcase. Other impurities in suspension do not, however, settle out so rapidly and some sludges may even be so light as to remain in suspension. Subsequently, upon the next starting of the engine the impurities are likely to be drawn into circulation again.

Carbon, which is another prevalent contaminating agent, is also a sludge creator, tending, in addition, to impair proper lubrication even when held in free suspension in the oil. Furthermore, this suspension of minute particles of carbon is claimed to render the problem of purification considerably more complex than it normally is in steam power plant service. In general, such carbon will not settle out readily from the oil, rendering simple gravity separation a difficult matter. Filtration, centrifugal action, or agitation in presence of a coagulent for throwing down the carbon, however, are all effective methods of purification.

In addition, these systems serve to remove water and other contaminating foreign matter. It must be borne in mind, however, that a certain amount of loss will accrue which must be taken care of by the periodic addition of a suitable amount of new or purified make-up oil.

Other Contaminating Factors

There are numerous contributory factors which determine the rate at which impurities accumulate in a circulation oil system. The particular type and design of an engine together with the quality of lubricating oil used are among the determining influences. The mechanical condition of the unit is important with reference to the condition of its pistons and rings, the tightness of the cylinder liner and water jacket joints, the water connections for piston cooling as well as the proper control of cooling water.

Incomplete combustion, whereby fuel is left in the cylinders in liquid or carbon form, due to improper atomization, will result in contaminating the lubricating system. Other factors entering into this important matter will include the engine operating temperatures, the cleanliness of the fuel burned, and the extent to which the oil in the lubricating system is effectively purified.

Methods of Reconditioning

Oil reconditioning is accomplished:

(a) By periodic treatment of the entire volume of oil involved, commonly known as batch purification.

(b) By continuous treatment of this oil, or

(c) By continuous treatment of only the dirtiest oil from the bottom of the return reservoir or oil sump.

The method to use will depend upon the volume of oil involved, the degree of contamination of the oil and the class of service or type of equipment being lubricated. Any one of the above methods is applicable to either the filter or centrifugal device.

Batch Purification

The batch system is generally used for the purification of oil from smaller engines where the oil supply is from gravity sight feed or mechanical force feed lubricators. The oil passes once through the engine without recirculation. This oil should not be discarded as real economies can be effected by saving it until sufficient volume has accumulated and then purifying it.

Even where the continuous purification system is employed, it may be desirable to subject oil periodically to batch treatment to assure removal of all impurities, for by no other method is their accumulation in an oiling system positively eliminated. The necessity for batch purification and the frequency of this kind of treatment depends on the facilities and the conditions of operation.

Continuous By-Pass System

On engines equipped with pressure circulating systems where a large quantity of oil is being circulated at a very rapid rate, the continuous by-pass system is without doubt the most practical way to connect the filter or purifier to the system.

The continuous by-pass system is arranged so that a certain percentage of the total amount of oil is continuously passed through. The rate of flow should be sufficient to handle the entire volume of oil in the system once every two to six hours, depending on the kind of engine and its average load factor. With such a system the accumulation of water and other insoluble impurities is retarded by providing for a definite withdrawal of a part of the oil in circulation and its purification before it is returned to the system.

It is desirable that the oil be taken from the lowest point in the circulation system, usually the bottom of the engine sump tank, from whence the oil is passed through either a filter or centrifuge whereby water and insoluble impurities are removed.

In one type of continuous by-pass system the feed line is located at the bottom of the sump tank and close to the drain line from the engine. The object is to deliver the dirtiest oil possible to the purifier. Some dirt will settle in the tank and the purifier will be eliminating this continuously. The location of a baffle in the tank assures that the cleanest oil in the tank will go to the engine. A heater may be provided so that the used oil can be further thinned before going to the purifier. Sometimes a cooler is also installed so that clean oil can be returned to the system at a proper temperature. However, if the amount of oil in a system is large, oil coolers are frequently eliminated and the heat depended upon to be dissipated in the sump tank while awaiting purifying.

With some types of installations where the rate of circulation is not rapid, the complete purification of the oil in the system is carried out. This is known as continuous total purification, and in such a case the entire lubrication charge is treated before it is returned to the engine.

Where gravity oiling is employed on an engine the used oil is pumped from the crankcase to an overhead supply tank. This tank has a conical bottom into which the impurities contained in the oil settle by gravity. A portion of the oil is drawn off continuously from the bottom of the tank and diverted to the centrifuge or filter after which it again enters the system for recirculation.

Filter Purification

The function of a filter is to pass the lubricating oil through certain material which serves to catch and hold solid matter. Filters differ in a sense from strainers which are usually provided in the oil lines of circulation systems to remove coarse particles. Filters vary widely in the methods used to cleanse the products, but the requirements of any successful filter embody the following:

a. A means for reducing (if necessary) the viscosity of the entering oil. Steam coils are frequently used for this purpose, and in some cases electric heaters have been used.

b. Ample precipitation area for the deposit of sediment. The oil should come to rest for a sufficient time to permit precipitation of foreign matter.

c. Suitable facilities for the separation of water. The water so separated must be readily trapped out.

d. A suitable system, preferably of cloth filtering mediums for so-called "dry filtration." The ideal method of arranging a filtering cloth is to maintain it in a vertical position without pleats and folds, so that accumulated dirt will tend to slide vertically down from the cloth or filtering medium and not retard the oil flow through the cloth.

e. In all but the smallest oiling systems, a multiple unit design should be provided, to facilitate filter medium changes and renewal without interrupting the operation of the system. This involves more than one filter unit so arranged that one unit at a time may be cut out from the system for changing filter mediums without interrupting the continuous flow of oil through the system.

Construction of Filters

The modern industrial or power plant oil filter will in general provide for combined precipitation and filtration. The oil as received from the lubricating system, etc., is run to a strainer box to take out any larger, heavier particles of foreign matter, or, to a heating tray, especially if it is a heavier, more viscous product, in order to promote subsequent precipitation and separation of as much water and sludge as possible.

After suitable heating the oil is passed to the precipitation compartment over one or more precipitation trays at comparatively low velocity. Foreign matter naturally settles to the bottom here; water is led off through by-passes or slots to prevent it being carried through to the filters.

After the oil has been freed of heavier foreign matter by precipitation it is passed to the filter compartment. In this latter, in rigid arrangement, are the filtering units. Filter bags or metallic frames covered with finely woven filter cloth are used for this purpose. Dirt and foreign matter accumulations on filter cloth will form an additional filtering media to a certain extent.

Filter material should be non-corrosive, as resistant to abrasive wear as possible, inexpensive, easy to install, non-soluble in oil, of such a weave as to give a uniform rate of filtration over the entire surface, and it should have no tendency to give off shreds or disintegrate in any way to contaminate the reconditioned oil.

Centrifugal Purification

Centrifugal purification is a mechanical process for accelerating the separation of impurities from liquids by rotating the liquids at high peripheral speeds. Centrifugal pressure is easily capable of being developed to a point several thousand times greater than the force of gravity, its application for separating, purifying or clarifying oils is, therefore, most desirable. Practically speaking, centrifugal purification is gravity turned sidewise and brought under perfect control as to the degree of pressure exerted and the effectiveness of its application.

The effectiveness of a centrifugal machine depends both on the amount of centrifugal force generated and on the manner in which such force is applied within the bowl. The amount of centrifugal force developed by any machine varies directly with the diameter of the bowl and the square of the speed of rotation.

There are several kinds of centrifuge machines, operating on the same principle. Such a machine usually comprises a bowl mounted on a vertical shaft and rotated by suitable mechanism. In some centrifuges the oil to be cleaned enters at the top of the machine, while in others the dirty oil is led in at the bottom.

The internal construction of the bowls used vary considerably, depending on the rotative speed of the machines, the viscosity of the products and the nature of the impurities. In one type, for example, a number of conical plates are used in the bowl. The dirty oil enters the feed cup at the top of the machine, passes underneath these plates and flows upward in thin layers toward the apex of each cone. The separation of the impurities from the oil in thin layers is rendered more easily than from bulk oil, in fact, it is claimed that the effectiveness of the force is increased to sixty thousand times that of gravity acting on a film of oil one inch in thickness.

The separation of the impurities from the oil is further improved if the oil is warm, and proper means for heating the oil before centrifuging is frequently provided for in order to reduce its viscosity.

When operating, the solid matter is thrown into sediment pockets. Water, being heavier than oil, is forced outward, and rises to the lowest discharge spout. The purified oil after leaving the plates discharges from the middle spout. The top spout is an overflow.

Another type of centrifuge consists of a long tubular bowl mounted on a spindle which is suspended from ball bearings and driven at high angular speed. In this type the dirty oil enters the bowl from the bottom. The centrifugal force developed is assisted by a special three-winged device and keeps the liquid moving at the speed of the centrifuge. By distributing itself in a thin layer the oil places its impurities under the maximum influence of the centrifugal force. The purified oil and the water discharge from separate spouts, while the heavier solid impurities are retained within the bowl. The liquid in the bowl automatically drains away when rotation of the machine is stopped.

As the effectiveness of the centrifuging process depends on the character and kind of contamination, the speed at which the oil is fed through a centrifuge must be carefully gauged and the rate of flow properly adjusted by the operating engineer.

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